Addressing the human dimension

In nutrition sciences, agroindustries, and international agricultural research

Richard H. Young

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Abstract

Procedures to preserve food have been used for over 100 000 years; yet only in the last 100–150 years have the processes been elucidated. Systematic efforts by food and nutrition scientists have increased understanding and increased control over food beyond the farm gate. In developing countries, however, would-be improvements must be predicated on a systems approach if the effects of modifying part of the system are to be anticipated. The main component of the system is people.

As the focus is on systems and people, multidisciplinary research is needed to strengthen the links between farmer and consumer. Within this context, two sets of activities for the international agricultural research centres (IARCs) and for regional and national institutions in food and nutrition sciences are recommended.

IARCs should expand their work on fundamental properties that affect processing and product acceptance of local foodstuffs; act as a clearinghouse for information about agro-industrial developments; incorporate consumer studies and market analysis into their research; and disseminate methods that relate research to client needs.

Regional and national institutions should coordinate research on food-processing and postharvest problems related to the developing countries; set up pilot projects for testing commodities, technologies, and markets and for training purposes; and pursue closer ties with the private sector.

Résumé

Les procédés de conservation des aliments sont connus depuis plus de 100 000 ans, mais leurs principes n'ont été découverts que depuis 100 à 150 ans. Les spécialistes des aliments et de la nutrition, par leurs efforts systématiques, ont élucidé le comportement des produits agricoles après la récolte et permis de mieux le contrôler. Cependant, dans les pays en développement, les prétendues améliorations doivent être fondées sur une approche systémique si l'on veut que la modification d'une partie du système ait des répercussions tangibles. La principale composante du système est l'être humain.

Puisque l'accent est mis sur les systèmes et les gens, de la recherche multidisciplinaire s'impose pour renforcer les liens entre l'exploitant agricole et le consommateur. Dans ce contexte, deux ensembles d'activités sont recommandées aux centres internationaux de recherche agricole (CIRA) et aux instituts régionaux et nationaux en sciences de l'alimentation.

Les CIRA devraient élargir leur travail aux propriétés

fondamentales qui touchent la transformation des aliments locaux et leur acceptation par les gens; servir de plaque tournante à l'information sur les progrès de l'agroindustrie; incorporer à leur recherche les études de consommateurs et l'analyse des marchés et diffuser les méthodes qui permettront de lier la recherche aux besoins des clients.

Les instituts régionaux et nationaux devraient coordonner la recherche sur la transformation des aliments et les problèmes post-récoltes dans les pays en développement; mettre sur pied des projets-pilotes pour éprouver les denrées de base, les technologies et les marchés, et aux fins de formation; et viser à créer des liens plus étroits avec le secteur privé.

Resumen

Si bien los métodos de conservación de alimentos se han venido utilizando por más de 100 000 años, no ha sido hasta los últimos 100 a 150 que los investigadores han podido esclarecer los procesos que posibilitan esta conservación. Esfuerzos sistemáticos por parte de bromatólogos han aumentado, más allá de los límites de la granja productora, el conocimiento que se tiene de los alimentos y el control ejercido sobre los mismos. En países en desarrollo, sin embargo, las mejoras futuras deben promoverse con un enfoque sistémico si se quieren anticipar los efectos de modificar parte del sistema, cuyo componente principal es la población.

Como el hincapié se hace en los sistemas y en la población, es necesario realizar investigación multidisciplinaria para fortalecer los vínculos entre agricultores y consumidores. Dentro de este contexto, se recomiendan dos conjuntos de actividades para los centros internacionales de investigación agrícola (IARC) y para instituciones regionales y nacionales de ciencias de los alimentos y la nutrición.

Los IARC deben expandir su trabajo sobre propiedades fundamentales que afectan el procesamiento y aceptación de productos elaborados con alimentos locales; actuar como centros distribuidores de información acerca de innovaciones agroindustriales; incorporar estudios sobre consumidores y análisis de mercado a su investigación; y difundir métodos que relacionen la investigación con las necesidades del cliente.

Las instituciones regionales y nacionales deben coordinar la investigación sobre problemas que confrontan los países en desarrollo con el procesamiento de alimentos y la situación de postcosecha; establecer proyectos pilotos para probar productos, tecnologías y mercados, así como con fines de capacitación; y tratar de establecer vínculos más estrechos con el sector privado.

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In memory of the late
Amy Chouinard

Foreword

This paper was first presented in Rome in December 1989 to a workshop organized by the International Union of Food Science and Technology (IUFOST) and the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR). At the meeting, a group of experts were invited to develop recommendations on improving food-crop utilization and agroindustrial development. The report of the meeting has been presented to the TAC as a contribution to the CGIAR's strategic review process.

The paper by Richard Young, which was subsequently slightly modified after review by several leading experts in the field, was considered by IDRC to be well worth wider dissemination, and therefore now appears in this form.

IDRC has, since its inception in 1970, recognized the need for research on food systems that goes well beyond considerations of only production. In recent years, and largely in response to production surpluses of certain commodities in certain regions, recognition has been growing worldwide of the need to shift from a purely production to a market orientation in designing and executing programs on agricultural research and development. At the same time, awareness has been growing of the role, actual and potential, of small-scale agroindustries in generating income and employment and of the potential of this sector to contribute to alleviating poverty and improving nutrition.

This paper draws on a wide range of literature and cites many examples of actual research and development projects in this field — many of them supported, at least partially, by IDRC. An excellent overview is provided of the

main issues and opportunities confronting the development of small-scale agroindustries, and the linkages between the production and postproduction sectors are clearly articulated.

I believe Richard Young's paper, and the recommendations contained in it, will be of interest to many researchers, policymakers, and development agents working in national, regional, and international institutions throughout the world. If it increases awareness of the importance and potential of the postharvest and agroindustrial sectors, and the urgent need to involve the target beneficiaries directly in the research and development process within these sectors, it will have served a very useful purpose.

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Introduction

Olduvai Gorge, in Tanzania, has provided the most revealing record yet found of early humans and their predicament (Leakey 1971, 1979). The major significance of this archaeological discovery resided in the remarkable disclosure that, nearly 2 million years ago, the social structure of our ancestors already included the concept of a "home." From evidence gathered at Olduvai, the theory has emerged that they had been hunting, gathering in groups at a home-base, and occasionally making shelters for at least 1.75 million years.

There is a good deal of evidence to suggest that the technical skills of early humans developed considerably during the period spanned by the Olduvai deposits (Reader 1988). In particular, the variety of sophistication in the tools excavated seems indicative of the evolution of skills ultimately responsible for the technological culture that surrounds modern humans. The archaeological finding at Olduvai of lakeside living sites littered with stone tools and animal bones prompted a shift in anthropological focus from the killing aspect of hunting that tools had facilitated to the sharing aspects of social behaviour that underpinned the system. The hunter-gatherer lifestyle was said to be characterized by cooperative behaviour and altruism at a very early stage of human evolution. The sharing hypothesis was founded on these observations, its basic premise being that, although tools had improved access to a highly nutritious food source, it was the willingness to share labour and food which had set our ancestors on the road to humanity (Isaac 1978; Bunn 1981).

The home-base theory has been contested. For

example, Potts (1984) has surmised that fossils and tools found in the Gorge could have been assembled by natural causes rather than hominid activity. Moreover, some assemblages at Olduvai could be interpreted as stone caches, representing an energy-saving strategy of leaving a supply of stone tools and raw materials at convenient locations in the foraging area, to which hominids would carry meat (and other foods) for further processing, away from the attention of competing carnivores. Fossil studies by Shipman (1984) led to the suggestion that hominids were not in fact dismembering carcasses and carrying meat back to a home-base but eating it on the spot; in other words, scavenging. More recent work has further clouded the evidence on which the relationship between early tool-making and hunting or scavenging is based (Andrews and Cook 1985; Behrensmeyer et al. 1986).

Although the food-sharing–home-base hypothesis remains unproven, there is substantial evidence to indicate that the concentrated nature of essential nutrients in a meat-rich diet allowed early hominids to redirect time spent in finding and consuming bulky food to the learning of fresh skills. In evolutionary terms, humans' dependence on hunting and gathering food continued until fewer than 10 000 years ago, when we generally became food producers. Hunting and gathering societies still exist today; albeit few are entirely dependent on this subsistence pattern. Some of these (in the Arctic, for example) do not practice agriculture per se.

Through domestication, grasses became the cereals that are now the staple of most humankind. Also came the domestication of root crops and of wild animals for both food and burden. The new systems of food production led to sedentary populations that are thought to have preluded the division of labour and subsequent development of the religious and artistic pursuits (Cohen 1977).

The discovery of agriculture — the neolithic revolution — enabled humanity to expand. Agriculture was reliable and usually yielded more food per unit area than hunting and foraging. It also permitted humans to

cultivate areas where existing stocks of food would have been inadequate. The human population multiplied — partly because fewer people died from starvation (Angel 1984). Population pressures on food supplies have been a concern ever since and research has striven to meet the challenge of providing enough food for all the people relying upon agriculture.

The move to modern times brought with it the dichotomy of developed and less-developed countries — contrasting social, economic, health, and nutritional conditions. In the early 1960s, it was realized that food production had accelerated beyond requirements to satisfy life in the developed regions but serious shortfalls existed in the poorer countries of Africa, Asia, and Latin America, with imminent risks of widespread starvation. Thus, the International Agricultural Research Centres (IARCs) were conceived to apply the benefits of modern agricultural science to Third World food problems. As Plucknett and Smith (1982) point out, the IARCs' strategy to create a green revolution managed to forestall a catastrophe through development and rapid dissemination of high-yielding varieties of wheat and rice. In India, for example, wheat supplies tripled between 1961 and 1980, primarily because of the adoption of high-yielding varieties.

The postharvest factor

Increasing food yields from available land has been a preoccupation reflected in the policies of international agricultural research. That adequate yields from agriculture are fundamental for health and well-being is unquestionable. Nevertheless, satisfactory agricultural productivity at the farm, or even the national, level does not guarantee nutritional adequacy nor economic development.

After harvest, and before consumption, food is normally subjected to handling, processing, and marketing, which affect its price, availability, perishability, and palatability. The efficiency of these operations in regularly transferring food to the consumer in the right quantity, at the right price, and in the right form is conditioned by economic, social, and political factors. It is this postharvest factor of agricultural research that, although of prime importance in delivering wholesome food to needy consumers, has been overshadowed by the large effort to increase crop yields.

Not that the value of conserving food has been ignored. For 100 000 years, procedures — however empirical — have been used to extend periods of food availability after harvest or slaughter. Even earlier humans ground grains, crushed berries, and cooked food. Apparently, the first controlled use of natural fire started some 500 000 years ago, to be followed much later by the ability to make fire at will. The new flavours of cooked meats and vegetables were discovered and enjoyed. Palatability added a fresh dimension to eating as a pleasurable, as well as a life-perpetuating, experience.

Postharvest procedures became more sophisticated and diversified with the neolithic revolution. With the cultivation of starch-rich cereals and roots, cooking became essential, as humans possess only limited capacity to digest uncooked starch. The principles of preservation by dehydration, chilling, freezing, salting, smoking, and cooking were applied long before they were understood, and

they permitted increasingly successful control over the quality of food. That meat spoiled sooner in warm weather than in cool weather must have impressed early humans. Appreciation of this fact led to the storage of meat in natural caves where the temperature was relatively low even in the warm season of the year (Lawrie 1974).

More recently, ice, gathered from frozen ponds and lakes in winter, was used to maintain low temperatures in cellars for food storage (Leighton and Douglas 1910). The empirical observation that salting preserved fish and meat without refrigeration was made several thousand years ago. By 1000 BC, salted and smoked products were available (Jensen 1949). Diodorus Siculus (1st century Roman) wrote about the Nile, "It contains every variety of fish and in numbers beyond belief, for it supplies the natives not only with an abundant subsistence from the fish freshly caught but also yields an unfailing magnitude for salting" (Williams 1988).

As Hulse (1982b) notes, the Amerindians practiced solar dehydration including atmospheric lyophilization (freeze-drying) of potatoes and used running streams to elute toxins from plants — the cyanogenic glucoside (linamarin) from cassava and the saponins from potatoes and quinoa and other edible seeds. Some 5 000 years ago, Egyptian farmers controlled infestation by covering and sealing each grain-filled amphora with a goatskin, the carbon dioxide generated by respiration effectively asphyxiating all predators present. Alcoholic and panary fermentations had been commonly practiced around the Mediterranean thousands of years before the scientific principles of microbiology and enzymology were understood.

The evolution of food and nutrition sciences

Despite the human inclination to preserve and process foods, only during the last 100–150 years have people had any knowledge of the agents responsible for perishability

of food and of the relationships between such agents and the procedures used to limit spoilage. Indeed, it is only since 1945 that the accumulating scientific knowledge of foods has begun to emerge and to be deliberately assembled into a coherent discipline. Against this background, however, a question must be posed. Is there really any need to understand and apply the principles of food preservation and processing as we have managed to progress and proliferate so long without comprehending them?

In this context, three factors differentiate the world of the last 150 years from that of the previous 10 million. First, with the industrial revolution, the development of manufacturing industries and mass-production methods, together with the infrastructure needed to support them, has meant that in most countries the majority of people must now earn their livelihood in urban areas at some distance from where food is produced. The commodities must thus span time and space. Second, it has become understood that most disease derives either from pathogens or from an absence of specific factors in the food eaten, such as vitamins and essential amino acids, in addition to the long-recognized effects of an absence of food itself. Epidemiology, toxicology, hygiene, and nutrition have all emphasized the quality factor in nourishment and, in so doing, have dramatically curtailed disease and infant mortality. Lastly, the third factor in our world that is related to food — rapid population growth — has made urgent not only the production of more food but production of better quality food and the development of means to preserve it longer.

Local, traditional methods of food production and preservation have become largely subsumed by the mass-manufacturing methods practiced in industrialized societies. All aspects of food must be understood scientifically and efficiently controlled. For such scientific control, a concomitant need has emerged for people who are trained in food and nutrition sciences. In fact, some countries have made it mandatory that the operations involved in food manufacture be placed under the jurisdiction of scientifically qualified personnel.

International food standards have gained recognition in the *Codex Alimentarius*, which has been established to facilitate world trade in foods and provide added protection for consumers' health (FAO/WHO 1988).

The interrelated components of food and nutrition sciences

The sciences concerned with food cover every stage from the germination of seeds, or the conception of animals, through growth and maturity, harvesting or slaughter, preservation, preparation, cooking, mastication, and digestion to assimilation and human nutrition. It is impossible to consider one stage adequately in complete isolation from the others. Moreover, these stages in turn involve other fields of knowledge — sociology, ethnology, economics, management, engineering, law, medicine, education, environmental conservation, and fuel technology, to name but a few. Food and nutrition science, therefore, like the agricultural and medical sciences to which it is closely related, cannot be dissociated from the social sciences or from political considerations. Recognition of these links is crucial for the successful application of the food and nutrition sciences in the developing world.

Food and nutrition science itself is mainly concerned with the chemistry, physics, and biology of preparing food for immediate or future use; with its processing and preservation from chemical and microbiological deterioration; and with its storage in a nutritional and palatable state until it is consumed. Clearly, the professions of food and nutrition sciences include occupations from basic food research to ad hoc investigations; from product development, quality control, systems analysis, production management, and sales promotion to public relations; and from teaching to advising official bodies nationally and internationally on scientific and legislative matters. Food and nutrition sciences are multidisciplinary and practitioners are particularly well suited to cope with the

complexity inherent in food supplies and nutrition in the developing countries.

In the industrialized world, the contribution by food science is evident. The food supply has immense economic value, representing income to both primary producers and processors. As FAO/WHO (1988) notes, the food industry is the largest manufacturing industry in the European Economic Community (EEC). It employs more than 2.5 million people in factories and plants. The turnover exceeds 250 billion USD per year and half to two-thirds of all the EEC agricultural output is processed.

Agribusiness and people

During past decades, farming has merged with food processing into "agribusinesses." Thus, as Pyke (1977) comments, the intensive production of eggs and poultry is as much food technology as farming; carrots can be grown in such a way as to fit exactly into the standard cans in which they are to be packed; peas grown on contract for freezing are hardly more than an extension of the plant in which they are to be processed and packed; greater amounts of capital are required to buy not only the land but also the elaborate equipment to gather potatoes (a task once performed by children), to harvest apples or raspberries, to gather and shell green peas at the peak of their condition, and to harvest and thresh grain.

Without denigrating the positive effects of agribusiness on modern society, Pyke signals the need to consider the "feelings of the people who would wish to live and work in an agrarian society rather than a commercial or industrial one." Today, food scientists increasingly reflect both on those who work within the food industry and those who make up the community outside it, whose feelings and actions inevitably affect the operations for producing the community's food. Thus, mass manufacture of food is tempered by environmental and health concerns. Food

scientists involved in Third World development should be careful to match agribusiness with the community's needs.

Among the contributions made by food technology this century is the reduction of labour demand in food manufacturing through adaptive engineering and mechanization. As Hulse (1982a) notes, these innovations have assisted women in pursuing full-time professional careers without detriment to the family diet. Nonetheless, in the developing countries, the changes in food-processing systems have had unintended effects on cost, labour, and food availability. Greeley (1986), for example, points out that programs to reduce postharvest losses may adversely affect pricing policies, market demand, and labour. In India, rice hullers have displaced primarily female labour, the small gains in technical performance being at the expense of vulnerable segments of society (Pacey and Payne 1985).

Our concern for development must extend to all people, not merely educated professionals, bureaucrats, and industrialists. People are the main reason for, as well as being participants in, the food industry. Thus, they are a key component of a multistage, multiproduct commodity system. Failure to recognize the interdependence of all components in the system has resulted in raw material shortages, excesses of processed products, and inefficient manufacturing operations as well as inappropriate labour displacement (Austin 1981). Thus, any discussion on food and agroindustrial development in the developing world must focus on the human dimension and a systems approach.

Significance of agroindustries in the developing world

Gaikwad (1986) comments that rural development strategies adopted on a large scale in India have generally neglected the potential role of agroindustries in community improvement. Farmers in some parts of the country, however, have made efforts independently to

improve their economic condition by establishing agroindustrial cooperatives. Examples from some 40 years ago include the Pravaranagar Cooperative Sugar Factory in Maharashtra and the Amul Dairy Cooperative in Gujarat. Their success encouraged replication and such enterprises now contribute significantly to the incomes of millions of small and marginal farmers.

The agroindustries generate value-added on agricultural produce and, importantly, provide the "anchor" for productivity enhancement, economic development, and welfare activities. They grew from rural entrepreneurship and creative leadership. These agribusinesses have acted as the linchpin for establishing backward (credit and farming inputs) and forward (marketing) links, infrastructure (roads, power, and irrigation), social welfare, and supplementary economic activities.

Clearly, agroindustry contributes significantly to a nation's economic development (Austin 1981):

- First, agroindustries are a nation's primary method of transforming raw agricultural products into finished products for consumption;
- Second, agroindustries often constitute the majority of a developing nation's manufacturing sector;
- Third, agroindustrial products are frequently the major exports from a developing nation; and
- Fourth, the food system provides the nation with nutrients critical to the well-being of an expanding population.

Because industrialization springs from a country's natural agricultural endowment, agroindustries are particularly important to the economics of lower-income countries. They decline in relative importance as countries continue to industrialize. Thus, processing operations serve to open new crop opportunities to farmers and, by doing so, create additional farm revenue. In several cases, this has enabled subsistence farmers to increase their income by entering commercial markets

and, in other instances, it has allowed lands unsuitable for traditional crops to be brought under cultivation.

Given the predictions for rapid expansion of the urban populations of the developing countries by the year 2000 (PRB 1988), one can expect a significant growth in food-processing industries. Urbanization gives rise to marked changes in food consumption, with demands for greater variety and convenience. The foods require higher levels of transformation than those achieved through traditional processing. As Harris (1988) points out:

> The food industry [in India] is developing very rapidly for two reasons. The first is because of the consumption preferences of the top income decile (some 78 million people) who consume 25 per cent of total food expenditure; their consumption preferences are for fruit and vegetables, milk and dairy products and increasingly for processed foods. The second reason is the small but growing export of food, e.g., spices and fish, onto the world market. Such exports are penetrated by agro-business interests and will become increasingly conspicuous to foreign donors. Their positive impact on poverty is indirect, if at all, but they are certain to move rapidly up the priorities of the Indian food policy agenda.

Harris's prediction appears accurate, as the government of India recently created a ministry of food processing. Agroprocessing potentially can boost the Indian economy through both domestic and export markets; recognition of this has prompted strategies to accelerate its growth (Srivastava and Vathsala 1989). One can take exception, however, to the implied view that agroindustries alleviate poverty little if at all. Agroindustries generate employment and income, especially for the needy, rural sectors. Austin (1981) notes that, in developing countries in 1975, 9.7 million people were engaged in the food and beverage industries alone, this figure constituting 18.9% of all jobs in the manufacturing sector. The annual growth in employment in the food and beverage industry between 1970 and 1975 was 6.3% — far exceeding the population growth rate (2.8%). In the

lowest-income countries, annual growth in these jobs between 1970 and 1975 averaged 7.9%.

Austin rightly stresses the importance of small-scale industries (SSIs), which generally provide the majority of jobs in the manufacturing sector, and most of which are agroindustries. Thus, SSIs in Indonesia account for about 75% of manufacturing employment, even though they contribute only 16% of the sector's value added (Snodgrass 1979). Improving the viability of small- and medium-sized agroindustries, therefore, has particular promise for achieving employment objectives. Notably, agroindustries frequently offer employment and income opportunities for women. In Sri Lanka, women constitute 42% of the labour force of the food-and-drink industry; in Cyprus, 36%; in Honduras, 21% (Austin 1981). Income earned by women has specific health and nutritional significance because it tends to be used for family welfare purposes (Young 1987).

The economic significance of agroindustries is multiplied by the contributions of service industries involved in product marketing, financing, engineering, and provision of agricultural inputs. When production capacity exceeds local consumption and potential for export arises, processing of raw materials into stable and acceptable forms becomes crucial. Even minimal processing adds economic value to the produce and generates foreign exchange, and — over time — export agroindustries tend to increase

the domestic portion of value added by increasing the degree of raw-material processing. Such incremental industrialization not only increases value added but also creates products that are further differentiated, have higher income elasticities, and are more insulated from the price fluctuations of less processed commodities.

Nutritional considerations

Malnutrition still exists: an estimated 450 million to 1.3 billion people are undernourished (estimates from the Food and Agriculture Organization (FAO) of the United Nations and the International Food Policy Research Institute (IFPRI)). Malnutrition is intimately linked with inequitable access to productive assets, low income, social discrimination, and poverty. Recent evidence indicates that nutritional improvement is strongly correlated with enhanced agricultural productivity (Behrman et al. 1988). Overall, there is growing recognition that improved access to food for the poor and amelioration of malnutrition can occur only when nutritional concerns are specifically integrated into agricultural and rural development projects (Ruigu 1986). Accepting that income and employment generation, particularly for the rural poor, are essential to eliminating malnutrition in future implies a major role for the development of small agroindustries.

Nevertheless, agroindustrial projects could have adverse nutritional consequences if not carefully designed and based on socioeconomic, as well as financial, analysis. A simple example is the potential for agroindustries to promote farmers to shift from the production of staples to cash cropping, thus lowering supplies and raising prices. Additional income from cash cropping is not necessarily correlated with improved family diet. For example, Dewey (1979) believes that, as peasants abandon subsistence crops to produce cash crops, the resulting economic, social, ecological, and dietary changes often lead to poorer health and nutrition. Behrman et al. (1988) also indicate a weak connection between income increases and nutrition.

On the other hand, studies in Kenya have demonstrated that household food security can be improved by commercialization of agriculture — in that case, a change from maize to sugarcane production (Kennedy and Cogill 1988). Incomes of sugarcane producers were significantly higher than those of noncane producers and a portion of the increment was used to increase household calorie intake. A recent case study from Guatemala shows that, with appropriate access to resources and markets and effective assistance in institution-building at the community level, the poor can improve both income and welfare through cash cropping — in this case nontraditional vegetables for export (von Braun et al. 1989). Clearly, however, the nutritional effects of commercialization and increased income may vary between cultures and communities, and additional interventions (e.g., pricing policies, education, and communication) may be required to ensure that these are positive.

The social, human, and nutritional consequences of food-processing ventures and food-system changes must be predicted at the outset through the application of relevant research. The components of such research and the means by which it may be incorporated into international agricultural research systems are the focus of the remainder of this publication.

Agroindustries and postharvest systems

The intersectoral framework — the seed-to-consumer system — within which agroindustries operate defines the research and, therefore, deserves mention. Production and raw material characteristics must be geared to processing requirements and consumer needs. The operations and environmental conditions to which food materials are subjected affect their availability, acceptability, and price. The "food pipeline" constructed by Bourne (1977), depicts the sequence of postharvest

operations and the physical and biological means by which losses occur (Fig. 1).

The actual movement of food from harvest to consumer may, however, be simpler (e.g., household cultivation for household consumption in subsistence agriculture) or much more complex than that represented. Complexity may be increased by irregular movements of food, division of commodity batches and routing through the system by different paths and schedules, or infusion of commodities into the system from different sources. In Asia, for example, both agrarian society food systems per se (Fig. 2) and mixes of agrarian and industrial society food systems (Fig. 3) are seen with industrialization being on the increase and, in turn, expanding the numbers and types of market exchanges (Young and MacCormac 1987a). The

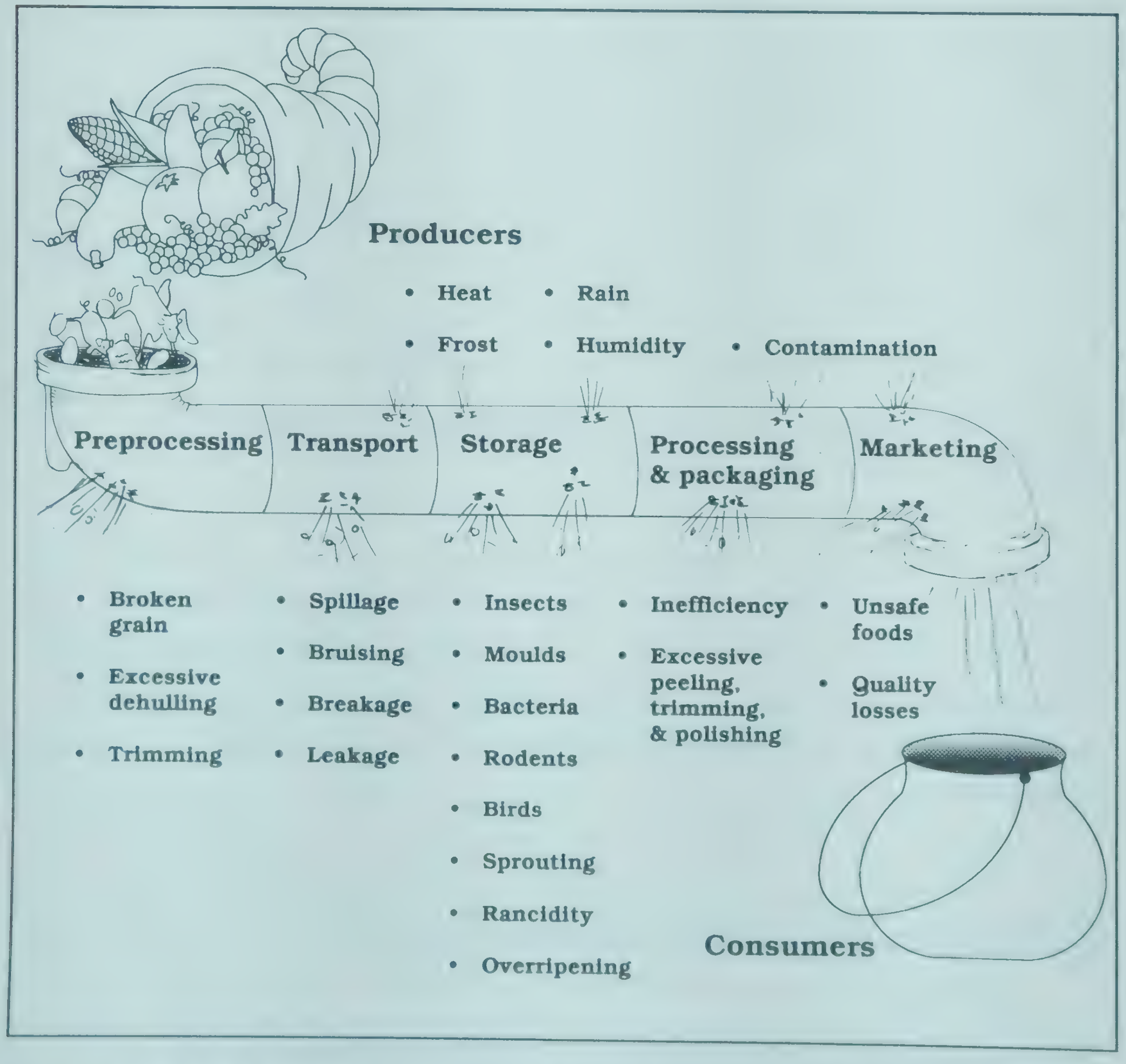


Fig. 1. The food pipeline (adapted with permission from Bourne 1977).

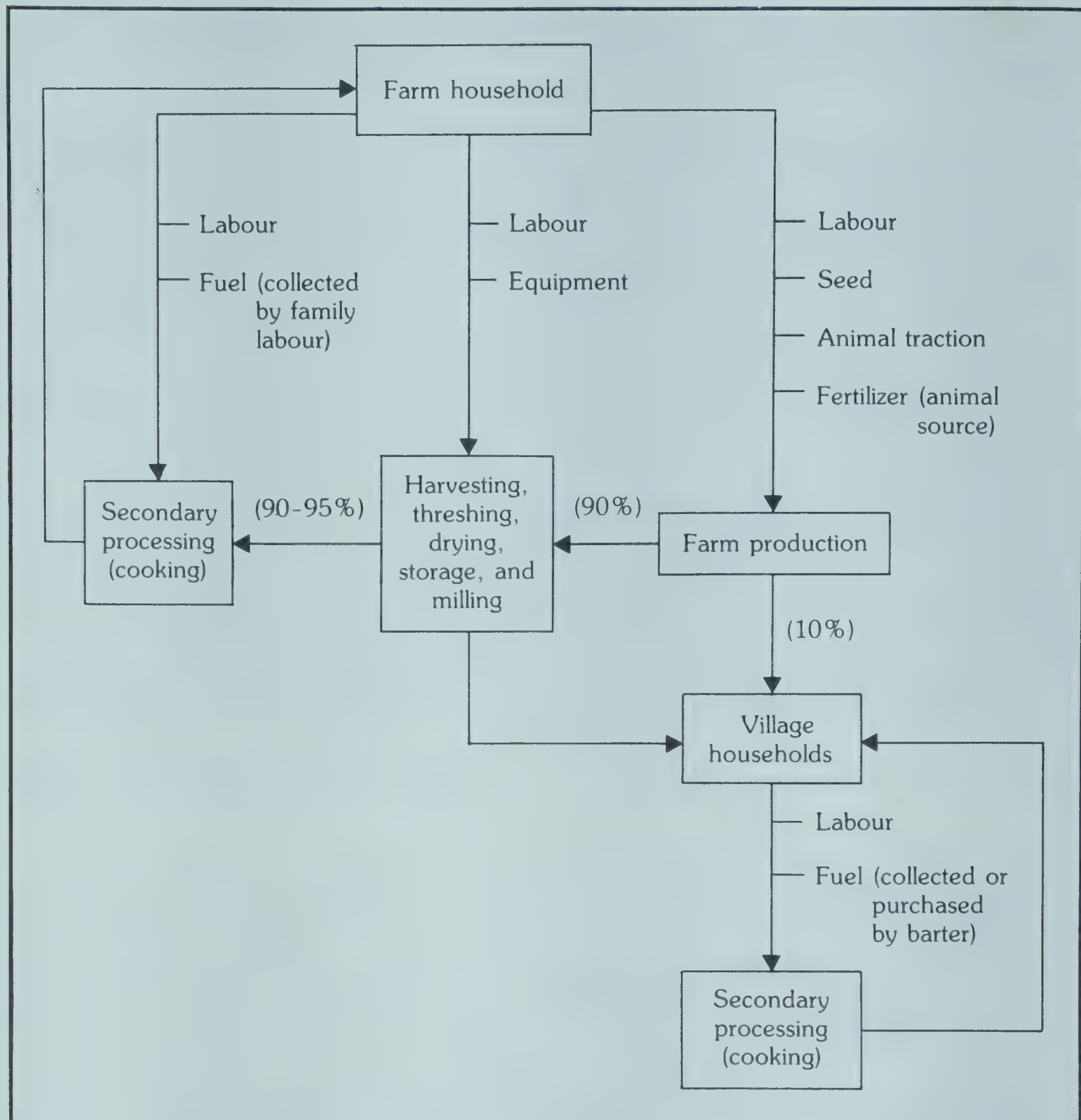


Fig. 2. Agrarian society food system (source: Young and MacCormac 1987a).

picture is a reminder that the food in the system is propelled by socioeconomic, cultural, and political forces; regulations and other bureaucratic procedures can slow or accelerate food's transmission from producer to consumer.

Reducing postharvest losses

Programs to reduce postharvest losses basically address two major categories of causes: primary and secondary.

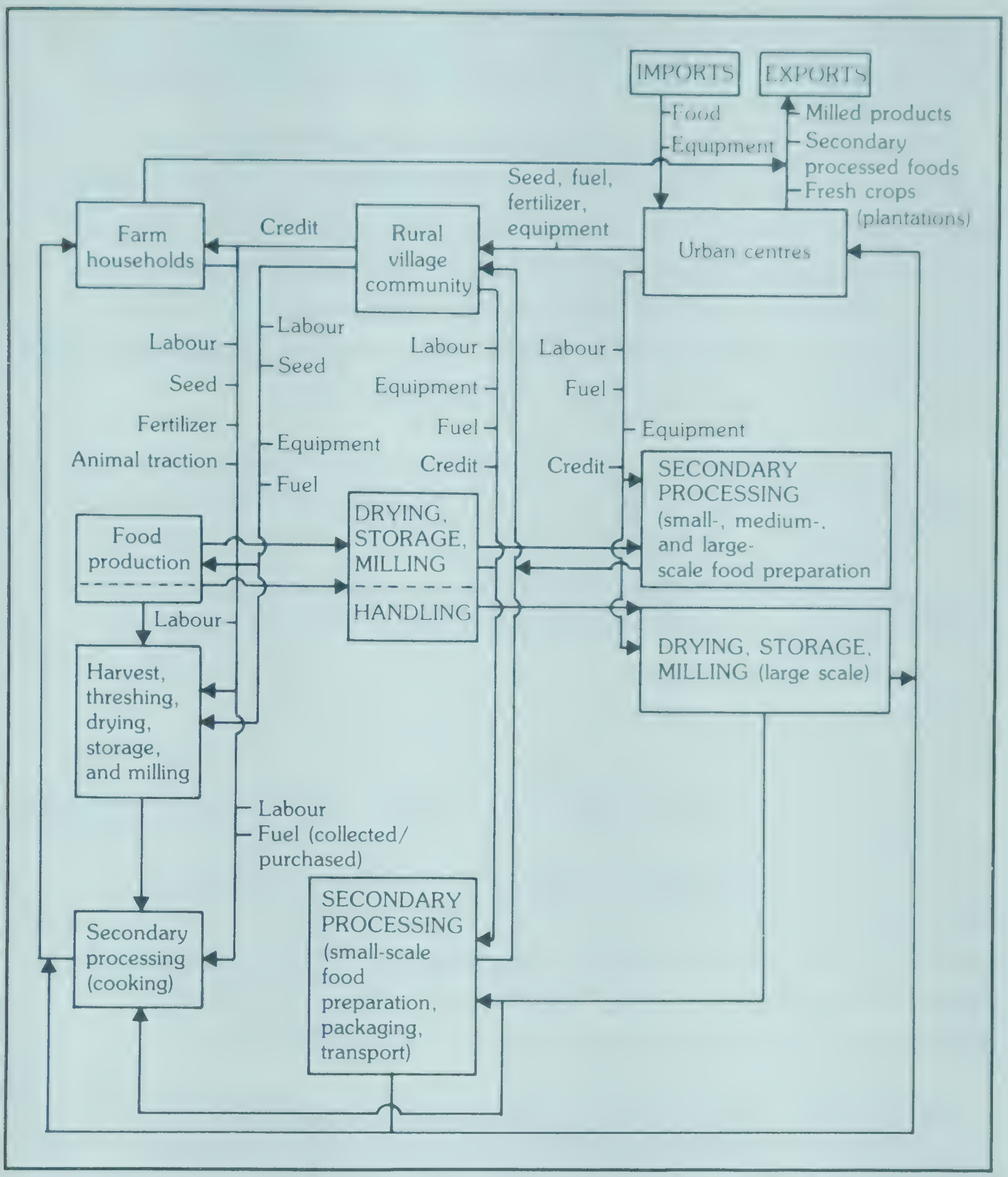


Fig. 3. Agrarian–industrial society food system (source: Young and MacCormac 1987a).

Primary causes include biological and microbiological (damage or consumption by insects, mites, rodents, birds, animals, moulds, and bacteria); chemical and biochemical (undesirable oxidative and hydrolytic reactions, fat autoxidation, rancidity, Maillard reaction, and food contamination with pesticides or toxic substances); mechanical (spillage, abrasion, bruising, excessive polishing, and peeling or trimming); physical (excessive or insufficient heat or cold and improper atmospheric and storage conditions); physiological (sprouting of grains and changes

caused by respiration and deterioration); and psychological (human aversion or refusal to eat particular food).

Secondary causes usually result from inadequate or nonexistent input, leading to conditions favourable to primary causes, e.g., inadequate drying equipment or poor drying season, improper storage conditions, inadequate transportation and marketing systems, and presence or absence of legal standards affecting the eventual retention or rejection of food for human consumption.

Attention to losses grew from the crop yields generated by the green revolution. The yields were accompanied by increased losses both during and after harvest. Increased grain output exerted pressure on already inadequate postharvest systems. The information on the patterns, magnitude, and causes of postharvest losses is imprecise, because many variables are involved — including crop, country, culture, place, time, and season. Also, methods of evaluating losses differ and, hence, values vary widely among assessments. The constraints to more precise and meaningful assessments have been discussed by Salunkhe et al. (1985). The effects of cultural, social, and economic factors in food conservation, and economic losses at farm level and their evaluation, have been described elsewhere (BOSTID 1978; Griff 1978).

In the developing countries, many postharvest operations — including threshing, shelling, drying, storage, and even primary processing — take place at the farm level. Preventing quantitative losses at the farm level has, therefore, frequently been the main target for intervention. However, data on rice systems from Bangladesh have been used to challenge assumptions that postharvest losses on farms are large; that they can be prevented cost effectively by technical change; and that prevention of losses will mean more food for hungry people (Greeley 1987). In fact, loss-reduction programs were shown to be potentially damaging to the welfare of some of the poorest rural households because they tended to remove food or employment from these groups.

Such findings emphasize that the programs must be

directed toward systems improvement and community welfare (including the creation of employment and income opportunities and enhanced nutritional status) rather than toward loss reduction per se (Young 1988). Of course, quality maintenance during postharvest operations may improve the farmer's income and market acceptability of the produce. Unfortunately, qualitative deterioration or loss has not been well documented because it more difficult to assess than quantitative loss.

Using food crops adequately implies measures to meet consumers' tastes and to match food quality and availability with market requirements. This is more than mere loss reduction. Groups offering financial support to agroindustrial ventures must be willing to underwrite costs of procedures not only for loss reduction but also for quality assurance.

Progress and needs in postharvest research in developing countries

In the developing countries, institutions, university and governmental departments, research programs, and networks dedicated to the postharvest sector are growing, as are attention and support from donor agencies. The result has been a wealth of information on postharvest issues relevant to the developing countries, and technologies designed to offset food losses and to process agricultural commodities in these environments.

In many instances, however, postharvest research has been conducted in pilot plants or laboratories, somewhat removed from the communities perceived as clients for the results, and with little or no collaboration with other disciplines in the agricultural, management, nutrition, and social sciences. Perhaps for these reasons, experiences with implementation of the results have

generally not been positive, although they are educational. A look at some experiences in drying and storage, dehulling and milling, cassava processing, and networks contains lessons for planning research.

Drying and storage

Moisture content of agricultural products is a key factor in deterioration during storage. For grains, it should be reduced enough so that the rate of respiration is too low to generate the heat that results in deterioration. In the developing countries, where maintenance of storage at or below 19°C is rarely economically feasible, the moisture content of food grains for safe storage is normally based on the equilibrium moisture content at 27°C and 70% relative humidity, e.g., 14.0% for paddy and 13.5% for sorghum. Drying methods are usually a combination of sun- and air-drying, although in some cases supplemental heating is employed. To benefit fully from the introduction of high-yielding varieties that mature and must be harvested during wet seasons and the production of second or, even, third crops ("double" and "triple" cropping) requires artificial drying.

Solar technology for artificial drying has received research attention because of its negligible running costs compared with those for traditional fuels, which have become increasingly costly and damaging for the environment (Bassey 1982; CSC 1985). Solar tents, solar-chimney dryers, and solar-box dryers are now available and have been cited as being attractive for small-scale operations because of their simplicity and lack of mechanical components.

Nevertheless, solar dryers have few advantages over conventional sun drying in commercial operations. The drawbacks include capacity limitations, low resistance to adverse environmental conditions, inability to prevent infestation, and poor internal air flow. Even in humid conditions when natural drying is impaired, the investment in solar-drying equipment may not be

justifiable. Wet-season crops require forced-air drying with heated or ambient air, i.e., mechanical drying, in which the drying rate can be controlled by manipulation of air temperature. Then, grains can be dried irrespective of weather; losses caused by insects, birds, rodents, or uncertain rains are eliminated; little space is required for drying; and high turnovers may be achieved.

Despite the evident need for them, dryers have not been widely accepted in Asia and Africa. Factors mitigating against them have included high capital cost, questionable performance (sometimes attributable to inexperienced operators); disparity between drying capacity and threshing, milling, and transport capacities; and delays that undermine the benefits. For these reasons, much of the current research focuses on low-cost, batch dryers that can be fabricated locally. Simple equipment, properly used, can provide dried grain of good milling quality with minimum delay, or can be employed to complement large central drying plants at the peak of the harvest season, drying grain to about 18% moisture, which affords protection from biodeterioration for several days.

Clearly, however, dryer research and design must fit the context of prevailing agricultural, food, and socioeconomic systems. In analyzing the performance of grain-drying projects in the Philippines, Cardino (1987) comments that the successful use of dryers required large volumes of paddy, compatible dryer capacity with drying requirement, integration of the dryer as a support facility to a milling–marketing operation, and technical know-how in operating the dryer.

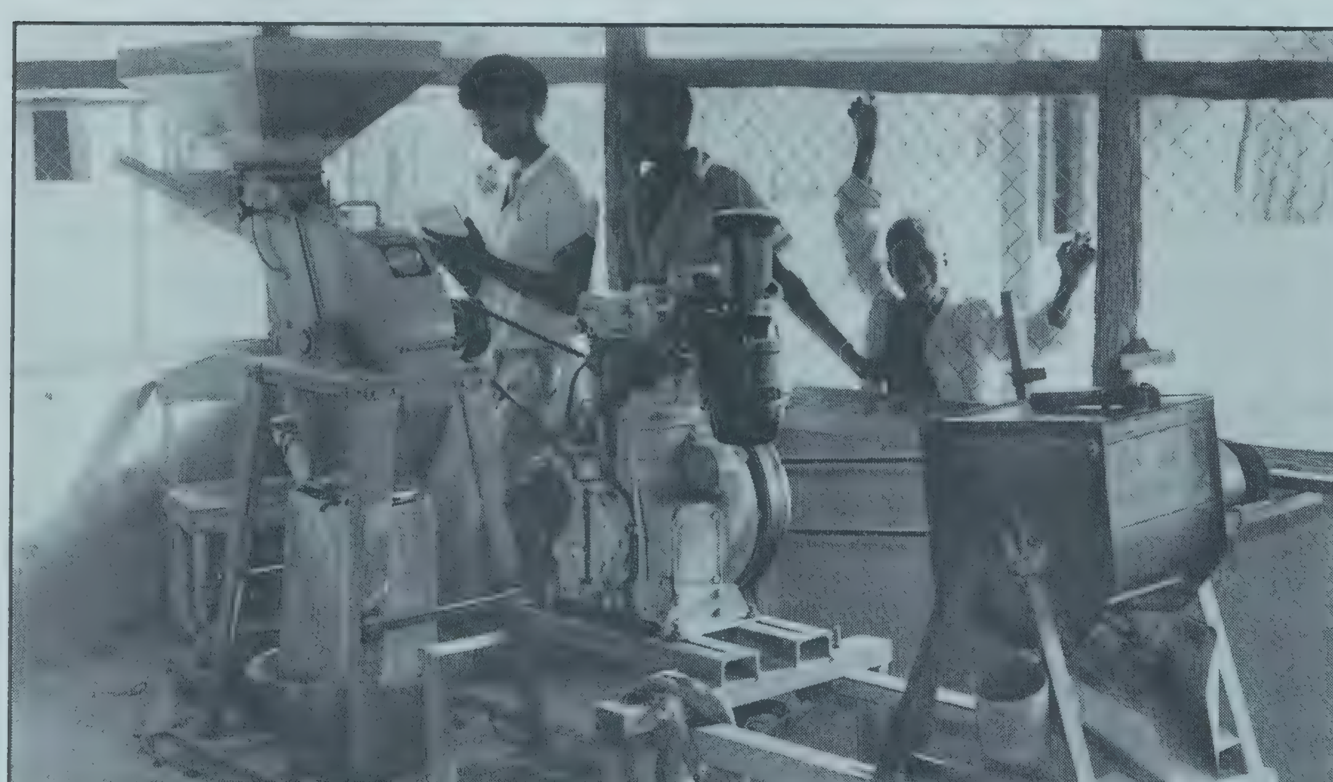
Contributing to the reluctance to use mechanical dryers was the presence of a market for wet paddy, the lack of incentive to dry under the existing pricing structure, an inapplicable grading system, and the existence of a market for low-quality milled rice. Removal of poor quality milled rice from the market through improved drying (at increased cost) could, in effect, eliminate an important source of low-cost calories. On the other hand, improved drying will improve total and head rice yields, which can offset the added drying cost.

Through blending of head rice and brokens, several milled rice grades can be marketed, those with the highest content of brokens still being the cheapest.

As de Padua (1988) states, "procedures for generating the requirements of the marketing system, for evaluating available component hardware, and for determining optimum combinations for different commodities, users, environments, and marketing channels have to be developed." To initiate this broadening of research, de Padua and others have elaborated a checklist of information needed to design a "system dryer," with due regard to social, marketing, pricing, and economic aspects.

Dehulling and milling of coarse grains

The milling of grain and grain legumes for human food and animal feed is one of the most basic of crop-processing requirements and, as such, has received much attention in terms of research. A notable example of postharvest systems research as a facilitator for development is seen in the experiences on improved dehulling and milling of dryland crops, largely supported by the International Development Research Centre (IDRC). Research projects in Botswana and India have focused on the development of a simple device for mechanical



dehulling suitable to the needs of producers and consumers of small grains and grain legumes and, more recently, on the introduction of the technology.

Botswana

Schmidt (1988) describes the dehuller's technical design, which evolved in collaboration with the intended clients, and experiences with introduction of the technology in Botswana. The equipment operates on the principle of progressive abrasion of the outer layers of grains or grain legumes; it incorporates a metal shaft on which a number of grinding stones, or abrasive disks, are evenly spaced. This rotor is enclosed by a semicircular sheet-metal barrel with a flat top, which is partially filled with grain; the abrasive disks, revolving at 1 500–2 000 rpm, rub against the freely moving mass of grain. The quantity of material removed is related to the duration of dehulling.

This relatively simple technology formed the basis for agroindustrial development in Botswana. In 1975, the Botswana Agricultural Marketing Board (BAMB), with IDRC support, initiated a program to establish sorghum-processing facilities. By 1986, 25 small-scale sorghum mills had emerged throughout the country, incorporating 35 dehullers. Of the total, 11 were privately owned, 8 were owned by indigenous development organizations, 5 by cooperative societies, and 1 by BAMB. The research and development that resulted in this mature, small-scale milling industry were characterized by a systems approach and consumer orientation.

Although the original equipment was designed in Canada, the Rural Industries Innovation Centre (RIIC) in Kanye adapted it on the basis of local needs assessment. The key characteristics of the Botswana research and development program, as provided by Schmidt (1988), included:

- A systematic identification of the key constraints to increased production and use of the preferred food, sorghum;

- A problem-led, in contrast to an all-too-common solution-led, approach;
- Analysis of the initial experiment by BAMB and the decision that rurally located service dehulling would be closer to the producer, save family labour, and create rural employment;
- Recognition by RIIC that technology generation is not enough and that as "product champion" it would have to persist until widespread adoption occurred; and
- Technology adaptation inside the country so that an indigenous cadre of personnel developed.

India

Like the work in Botswana, research with dehullers in India, undertaken by the Andhra Pradesh Agricultural University (APAU) with IDRC support, has met with some success. The small mechanical dehullers effectively remove drudgery from food processing and yield material that can be converted into a wide range of food products, including supplementary foods for infants.

The mini-dehuller has performed efficiently on sorghum, millet, and a range of legumes and the extensive field-testing has prompted a high demand for the technology in rural Andhra Pradesh. Fifteen sorghum-based foods have been developed and tested for acceptability and nutritive value. All have been rated highly acceptable and comparable with wheat- or rice-based foods. Recipes for porridges and baked goods, formulated to meet the protein and calorie requirements of infants and children, have been popularized through village demonstrations and newspaper articles. The project has demonstrated the feasibility of manufacturing "prestige" items, such as bakery products, from grains hitherto regarded as inferior and could stimulate use of yellow and red sorghums, which can be produced at lower cost than white varieties.

Preliminary market testing has indicated that demand for the products is growing. Whether this demand will support small enterprises is the question being addressed at present by a multidisciplinary project supported by IDRC in Andhra Pradesh. Based on the dehulling and processing elaborated by the APAU team, the project seeks to incorporate market analysis, close integration with industry and with government nutrition schemes, clear targeting and delivery of interventions, and systematic management. This has meant the development of a broader, interinstitutional program, which has not been without drawbacks.

The necessary expertise in market research, marketing, communications, and business management has been particularly difficult to integrate into the project. Consequently, efforts to promote the technology have lagged behind developments. For example, equipment is now being manufactured locally, but few people are aware of what it can do. Officials in government are generally unaware of the benefits, and pricing and subsidy policies still favour wheat and rice. Attention to marketing policy, and particularly to lobbying for changes in policy, should be coupled with advice and incentives to farmers to increase productivity and gear their production to processing and market demands.

Rice processing

In India, the impact of milling technology is perhaps best illustrated by rice-processing systems (Pacey and Payne 1985). In the 1960s, the rice hullers used widely in India by millers in the private sector began to be criticized as inefficient, and an automated package of premilling and milling machines, known as the Modern Rice Mill (MRM), was promoted. In 1970, under the Rice Milling Amendment Rules, the government attempted to enforce modernization in private mills by insisting that traditional rice hullers be replaced by the MRM. This policy hinged on the belief that the traditional hullers broke a high

proportion of the grain and thus were responsible for considerable losses.

The cost-effectiveness of MRM has been widely disputed, but what appears indisputable is the misinterpretation of the "social culture of rice in India." Indian society demands broken grain for certain culinary preparations. Many rice retailers in Tamil Nadu sell brokens at three-quarters the price of head rice. Also, poor people can sometimes buy brokens and would be unable to obtain head rice in the foreseeable future.

Clearly, the MRM experience in India is one of "technology-push" with little regard to market requirements. An open-minded, ex ante market analysis might have produced recommendations for quite different directions in rice processing. Moreover, one MRM would replace 30 hullers in a rural area — these would produce 8 000 t/year and create livelihoods for about 30 owners/managers, 60 salaried employees, and 300 (female) labourers. The MRM would process the same amount of rice in a year and would create employment for 28 administrators and qualified engineers, 68 technically trained employees, and 90 (male) labourers (Harris 1979). The nature of the labourer's job in MRM plants is more appropriate for men in Indian culture.

The focus on technology and small gains in yield through the application of engineering ignored the strong social influence of technical change in the rice-milling sector. If social and economic development is truly the long-term objective of postharvest programs, technologists and policymakers must better incorporate "needs and wants analysis" of clients and others affected by technology introduction.

Cassava processing

Experience with cassava processing in Colombia furthers the argument for integrated approaches to postharvest problems and opportunities demonstrating a potential strategy for the IARCs (Best 1988). Rapid

urbanization in Latin America has given rise to increased demand for livestock products, which in turn has fueled demand for animal feeds. A research program at the Centro Internacional de Agricultura Tropical (CIAT) has successfully linked cassava producers to the animal-feed industry and, thus, has provided a market for production from marginal lands. In addition, research to improve the quality of cassava through better storage has stimulated market demand for cassava as human food.

The program goes beyond research per se in linking researchers to farmers and industrial users and in conducting pilot and development projects. It possesses several characteristics that have encouraged implementation:

- First, identification of consumer market demand and elements of the marketing system;
- Second, close interaction with local food and feed industries;
- Third, linkage of marginal farmers with new and expanding markets and creating market assurance;
- Fourth, practical training in food-enterprise management by means of pilot projects;
- Fifth, understanding of quality changes in cassava that influence consumer acceptance; and
- Sixth, promotion of collaboration between relevant institutions.

The program initially drew little support from the IARC community; some members viewed it as being overly oriented to industry and undertaking a task better suited to national institutions. The results, however, emphasize the value to the IARCs of developing capabilities for market research, particularly to identify product opportunities for poor producers and consumers. The program demonstrated that pilot projects are essential to test products and processes, to develop systems, to train would-be entrepreneurs, and to encourage replication.

According to Best (1988), the program also highlighted

four functions for IARCs in supporting, at national levels, the interinstitutional and multidisciplinary approaches required for successful postharvest research — strategy research, methodology development, catalysis, and integration. Dispatching these functions, Best notes, will require a broadening of horizons, with greater emphasis on market research and contact with the private sector.

Networks

Few would dispute the usefulness of making and maintaining contact, be it with the private sector, the government, or the research and development community, yet seldom do researchers regard cultivating networks as more than an incidental part of their work — perhaps it should be written into job descriptions! Networking enables interaction; provides forums for exchange of information; presents opportunities for training and for elaborating joint efforts; it also can create a critical mass of researchers to address key problems.

Several networks have emerged in support of postharvest work in developing countries. Their mandates include exchange of information between donors, training within regions, and collaborative work on issues in food science and technology. Examples are the Group for Assistance on Systems Relating to Grain after Harvest (GASGA), the Association of South East Asian Nations' (ASEAN) Grains Post-Harvest Program (AGPP), and the Latin American Beans Network.

Group for Assistance on Systems Relating to Grain after Harvest

A voluntary network of organizations associated with donor operations, GASGA comprises organizations involved in providing professional advice, conducting field projects, training developing country personnel, and conducting and applying research.

GASGA is technical and international in character, but informal and limited in membership and it aims to stimulate improvement in the technical help provided to developing countries in postharvest handling of grain and to harmonize activities so that the most effective use is made of members' resources. GASGA also facilitates dissemination of information to donors and to personnel in developing countries and in interested organizations, such as the IARCs.

ASEAN Grains Post-Harvest Program

Formerly the ASEAN Crops Post-Harvest Program (ACPHP), AGPP aims to coordinate systems-oriented research on postharvest problems in the ASEAN region. The original program was sponsored by the Canadian International Development Agency (CIDA), the US Agency for International Development (USAID), and IDRC, each providing core support and a technical specialist. The Dutch government provided a rice-milling technician, and, later, Australia joined the program. An external review in 1986 recommended a restructuring that is currently under way with support from CIDA and IDRC, the other donors having withdrawn. Since its inception, the network of specialists has assisted participating countries in postharvest research, training, and development activities. A policy advisory board was composed of senior officers from relevant grain-marketing and donor agencies.

The mandate has been to identify problems and recommend solutions; to encourage collaboration among donors, governments, and scientists; to help build research capability; to maximize support; and to share information. The network has supported better understanding of grain yellowing, quantification of rice losses, improved comprehension of rice drying characteristics and drying systems, identification of insect pests predominant in rice, designs of village mills for Thailand, and development of warehouse inventory-

control systems. The team has been heavily engaged in the organization and implementation of training courses.

The driving force of the new program is still the postproduction needs of producers, consumers, and traders. The new program has shifted from a specialist-centred activity to a community-oriented one.

AGPP is now entirely operated by the ASEAN countries and encourages the national agencies concerned with postharvest research and development to participate in the planning and management of country projects. Technical staff within the program secretariat work with national postharvest committees (NPCs). Representatives from each NPC form a regional technical advisory committee (TAC), which plans collaborative activities. A program steering committee, acting on behalf of the ASEAN Food Security Reserve Board, takes overall responsibility for project approval and program management.

Latin American Beans Network

The Latin American Beans Network is an example of an intercountry association with a single purpose: to find solutions to the hardening of beans (*Phaseolus* sp.) during storage, which is a major problem in the region. Bean hardness is promoted by elevated temperatures and humidities during storage and extends the time necessary to cook beans to acceptable tenderness. This in turn leads to increased energy expenditure in cooking, loss of nutritional value, minimal consumer acceptance, and economic losses to bean producers and handlers. Previous research supported by IDRC had indicated that solutions are unlikely to be found without a fundamental understanding of the biochemical mechanisms involved.

In 1983, researchers at the Pontificia Universidad Católica de Chile and the University of Guelph, Canada, initiated a collaborative project to investigate hardening mechanisms in Chilean black beans; a year later, the Instituto de Nutrición de Centro América y Panamá

(INCAP) and the University of Manitoba started studies on acceptability criteria for beans and industrial processing. These four institutions have formed a network, sharing research procedures, resources, and results; standardizing laboratory methods; and developing a synergistic approach to research. Regular meetings and telecommunications have strengthened activities, as has input from workers in CIAT, Brazil, Costa Rica, and Mexico.

Not only are the biochemical interactions causing bean hardness being elaborated, but also consumer requirements are being documented, optimal storage conditions for different bean varieties are being determined, and low-cost techniques for maintaining bean quality are being developed. None of the collaborating institutions could have made such progress independently.

Palatability and consumer acceptance

Underlying all research and development in the food and nutrition sciences is the need to understand and satisfy habits and tastes. People eat foods that they like and reject foods they dislike. That this is generally disregarded is exhibited by the failure of countless projects to introduce foods or alter characteristics or nutritional value of existing foods.

A prime example is the rejection of high-protein foods designed by scientists for the poor and undernourished in developing countries (Orr 1972; McLaren 1974). Quite simply, no one will readily consume foods that are unappetizing, no matter how forcefully their nutritional value is emphasized by "experts." In industrialized countries, food manufacturers conduct rigorous organoleptic consumer trials before launching a product or modifying an existing line. This wisdom appears to be

frequently suspended when designing food products or promoting food-system changes in the developing countries.

In their haste to eradicate malnutrition, some nutritionists have described human requirements solely in terms of nutrients ignoring that people eat foods, not nutrients. Plant breeders have developed high-lysine cereals, increasing nutritional value of one component of diet to the detriment of functional properties that affect consumer acceptance. Even the lay public of many Western societies, becoming increasingly concerned about the nutritional value and safety of foods, now talks of protein, carbohydrate, vitamins, or fibre when it is really referring to meat, bread, orange juice, or celery.

Consumer requirements for foods are the result of complex physiological, sociological, and psychological motives. For processed foods and agroindustrial products, consumer needs are frequently expressed as palatability, i.e., preferences for a product's taste, smell, colour, texture, and appearance, these being conditioned by the product's price and convenience as well as associations with prestige and status (Shah 1986).

For example, successful manufacture of bakery products, regarded as prestigious in India, enhanced the status of sorghum. Conversely, *chaya*, a plant of the Yucatan region of southern Mexico, which grows wild and is rich in protein, was consumed by ancient Mayans along with maize and beans in a nutritionally sound diet. Over the years, however, it became known as "food for the poor," being consumed less and less, even though the people's diet was deficient in protein (Austin 1981).

Prestige can be created by advertising and other forms of communication, to which even the poorest may now have access. The move from breastfeeding to bottlefeeding is an example of potentially negative consequences. Nevertheless, communications techniques can be employed positively to influence traditional attitudes related to food consumption, hygiene, and nutrition (Hornick 1985).

To do so, one must understand consumer tastes and preferences. Projects aiming to improve food consumption, modify postharvest systems, or develop agroindustries must be designed based on accurate knowledge about attitudes, opinions, and behaviour. Obtaining this information about people is the role of market research.

Market research in the development context

Market research aims to identify consumer needs, market segments, and the purchasing process. Conventional marketing emphasizes the attainment of profits by identifying opportunities, and even creating needs, in a competitive, consumer-oriented industrial environment. Marketing has, therefore, emerged as a scientific discipline that responds to the needs of industrial companies for market information.

Market-research techniques can be applied at different stages of a project — market surveys, consumer surveys, consumer panels, discussion groups, sensory testing, and product testing. West and Earle (1987) have prepared an overview of the standard procedures and techniques. The techniques are important in developing products from an agricultural crop, introducing or improving an industrial process for crops or a nutrition intervention program, and introducing new equipment for the rural sector.

Regrettably, market research has been little valued by national governments and donor agencies in conducting development programs. Perhaps market research has been too closely associated with profit-making. In the agricultural sector, increases in food production have been expected to be readily absorbed by a demanding market. High-yielding plants with superior nutritional value, adaptable to wide agroclimatic conditions, are

worthless if their eating or processing characteristics are not suited to consumers.

For effective market research, we in development need better methods. The special characteristics of, and the constraints associated with, the social markets in developing countries demand special procedures. The reliability of the research could be questionable if certain factors are not taken into account. For example, deficiencies in availability, currency, validity, and homogeneity of secondary data cause difficulties in interpretation (Stanton et al. 1981). As Kaynak (1978) notes, the validity of primary market research depends upon:

- First, an organized and competent team of interviewers who are well acquainted with the respondent population;
- Second, a correctly selected representative sample;
- Third, carefully designed and pretested questionnaires; and
- Fourth, adequate financial facilities.

The difficulties in ensuring these conditions in the developing countries have been amply discussed (Young and MacCormac 1987a).

Epstein (1988) has prepared a manual that presents methods of market research in a concise and readable form, using examples and case studies from the developing countries. Market research is a key to future development, and the IARC system, because of its expertise on designing methods and its focus on commodity-oriented research and agribusiness development, should pursue market analysis more actively.

In 1986, IDRC organized a workshop on the application of market research in postharvest, agroindustrial, and development projects (Young and MacCormac 1987b). The workshop's objectives were, first, to create a greater awareness of the opportunities for using market research in

guiding food-technology projects in developing countries and, second, to highlight methods that are appropriate. Several of the conclusions and recommendations emanating from this workshop deserve emphasis.

- Market research is a scientific discipline and should be an integral part of development projects.
- Techniques of market research need to be tested and the results shared.
- A secondary data base should be elaborated for developing countries.
- Standard techniques in market research have validity, perhaps with modification, for application in developing countries.
- Qualitative analysis may have particular relevance in the developing countries.
- Market professionals should be trained for and in the developing countries and should be encouraged to research, monitor, and publish techniques.
- Financing agencies should consider adopting policies to permit the involvement of key business management and market consultants in development projects.

Further activities are planned, and interest is growing in organizations such as the World Bank and the Natural Resources Institute (NRI). The latter recently held a seminar to review ways of incorporating client-oriented research into its overseas projects. IDRC is pursuing its initiatives on market research and, in April 1990, organized a workshop in India to establish case studies in the South Asian region. The workshop participants have established an International Secretariat on Development Market Research to further promote the approaches.

Community participation and rural systems research

Although market research steers the development of agroindustries and acceptable food products, it derives its efficacy from peoples' perceptions and involvement, which ultimately form the basis for development in general. Chambers (1988) states "it is by starting with the priorities of the poorer, and enabling them to gain the livelihoods they want and need, that both they and sustainable development can best be served." In analyzing five case studies of community development projects, Chambers notes that a common characteristic responsible for their success was that they identified and met people's perceived needs. The integration of "needs-and-wants" analysis with development work represents a challenge for the design and application of research, as does the use of traditional knowledge. In reviewing the links between agricultural development and nutrition, Pacey and Payne (1985) comment: "learning from farmers could be the biggest improvement in research that is feasible within the present political economy."

Participatory approaches and sustainable development are now jargon in the development business. They rightly

reflect renewed and reinforced concerns for ensuring that the effects of development programs on people and the environment are positive, not damaging. Thus, farming systems research (FSR), rapid rural appraisal (RRA), and rapid assessment procedures (RAP) have emerged. Although development researchers have hesitated to employ marketing terminology, these techniques could be regarded as a form of market research, with emphasis on qualitative methods. In these cases, the product to be marketed is "development," "community improvement," or "agricultural productivity–sustainability," rather than a tangible product of manufacturing industries.

Crucial to success is that the "product" satisfies needs and aspirations as perceived by the "consumers," be they a marginal farmer or a mother of malnourished infants. In the field of nutrition, for example, the product may be a message to improve nutritional and health status. Community involvement and qualitative research are means to anticipate possible resistance to change and to develop an understanding of beliefs, attitudes, and practices critical for the design of appropriate messages and social marketing programs (Carrington et al. 1987).

RRA holds promise for application in many areas, including food processing and postharvest systems. It has been applied already in farming-systems research (KKU 1987), in agricultural marketing and food-systems analysis (Holtzman 1986), and in problem identification in community nutrition (Kashyap and Young 1989; Cervinskas and Young 1990). RRA is defined as any systematic activity designed to draw inferences, conclusions, hypotheses, or assessments, including acquisition of new information, in a limited period of time (Grandstaff and Grandstaff 1987).

Through RRA, reliable information can be obtained promptly for development or intervention programs. The technique enables researchers to obtain extensive information on a broad range of community activities, a better understanding of systems dynamics, and an appreciation of the interlinked factors conditioning the economic and social development of community members.

RRA is generally conducted by multidisciplinary teams; it facilitates interaction between the researchers and between the researchers and the community. In the context of agroindustrial development and food science projects, RRA appears to be a tool to achieve two goals stressed throughout this paper — addressing the human dimension and formulating a systems approach.

At present, most RRA expertise and experience reside in the developed world, as shown by the participants at the second annual RRA workshop, held at the Institute for Development Studies, UK, in June 1989. Given the qualitative nature of RRA, the technique may be regarded as less rigorous than technical, quantitative work but it can produce more reliable and realistic results than conventional data collection and analysis (Kashyap and Young 1989).

The lack of recognition of RRA procedures may be gradually overcome by establishment of training programs and networks. A start has been made in West Africa, where IDRC has sponsored a training workshop on RRA for postharvest and nutrition researchers. Like market research, RRA requires strengthening and modification for application in the developing countries. It is in this broad area of client-oriented research that the IARC system could play a lead, coordinating role.

Participatory and qualitative approaches should guide the evolving concepts of rural systems research (RSR), which represents a broadening of FSR to improve consistency in achieving the goals of productivity, profitability, stability, and sustainability for small farmers (IFAD 1989). According to Flora (1988), FSR needs to develop better mechanisms to influence policy, evaluate impact, integrate extension work, incorporate socioeconomic and income generation objectives, and understand markets and marketing systems.

The approach recommended by IFAD has merit and reflects an interesting shift from production to market orientation in the design and conduct of agricultural projects. It is also a framework in which major

contributions from the postharvest and marketing sciences will be necessary, and a firm role for agroindustrial development is seen. Specific attention to strengthening links between primary (farm), secondary (agroindustries and rural industries), and tertiary (services) sectors of the rural economy is envisaged. The approach emphasizes forward links to postharvest processing, biomass use, markets, employment, and income generation. Fundamental is participatory research, initially focusing on land and water management, integrated pest management, and postharvest systems. Farmers would essentially define and refine the research to be done.

This more integrated vision of international agricultural research assigns considerable value to the postharvest and agroindustrial sectors. As IFAD (1989) states:

> Post-harvest technology is an important area of research to help small farmers derive full economic benefits from their production efforts. Perishable commodities like fruits, vegetables and animal and fish products need particular attention. Research on the preparation of value added products from every part of plant or animal biomass should receive priority consideration.

Role of IARCs and regional and national programs

Agroindustries are of growing significance for the economic development of low-income countries and have clear implications for ensuring access to nutritious foods, generating employment and purchasing power, and supplying adequate foods to expanding urban populations. Those countries that have industrialized have recognized the need to scientifically control the manufacture and distribution of food products and have

trained specialists in food and nutrition sciences to meet this demand.

There remains an urgent requirement to strengthen this sector of scientific endeavour in the developing countries. At the same time, practitioners in the postharvest area must be sensitive to the human dimensions of agroindustrial development; able to appreciate and comprehend the complexities of the social, economic, and political scenarios in which agroindustries must operate; and capable and willing to link postharvest research to production and consumption issues. This is a challenge to those concerned with people, nutrition, and development.

In meeting this challenge, it is perhaps appropriate to differentiate between initiatives that could be implemented by IARCs and those that would be best pursued by national or regional organizations, either independently or in collaboration with IARCs. Ways in which current weaknesses in food and nutrition sciences and postharvest research systems in the developing countries could be addressed are discussed below. In particular, the respective roles and comparative advantages of IARCs, and national and regional institutions, in undertaking the required activities is examined.

Recommendations for IARCs

Expansion of work on the fundamental properties of local foodstuffs that affect processing and product acceptance. The biochemical nature and functional properties of food materials produced in different agroclimatic zones of the developing countries is not well understood, yet such an understanding underpins efforts to control food processes, determine food quality, and manipulate food commodities to cater for consumer demand. It also paves the way for innovation in domestic and overseas marketing of biotechnological products. The IARCs are well placed to further develop this area given

their strong breeding programs. Breeding for the most appropriate quality in the crop as raw material for processed products is more economical than improving properties through processing.

Surveillance of, and dissemination of information about, agroindustrial developments as entrepreneurs and private industry become aware of market opportunities and raw material availability. In some countries, such as India, agroindustries are proliferating as a response to requirements of the growing middle classes and urban populations. It would be feasible for the IARCs to expand comprehension of the social, economic, and nutritional consequences of agroindustrial development. The implications for national agricultural systems and marginal farming should be more fully appreciated and policymakers educated accordingly. Such monitoring and evaluation should form the elements of a postharvest and agroindustrial data base.

Incorporation of consumer studies and market research into all international agricultural research. Market research and marketing are essential disciplines for development programs. However, national institutions have considerable difficulty in acquiring suitable expertise, which is generally costly and available in the private sector. The IARCs could assist by developing and adapting methodologies and providing input and advice to national programs. The IARC system should increasingly incorporate this market orientation into its global strategies.

Development and dissemination of methods that relate research more to client needs. Awareness of participatory research, qualitative techniques, and RRA needs to be cultivated among postharvest scientists in the developing countries. There is a lack of available training on these methods and minimal institutional expertise in the developing world. Capacity strengthening in these areas could be a valuable undertaking for the IARCs' agricultural economics and social science programs.

Recommendations for regional and national programs

Coordination, in a formal system or network, of food processing and postharvest research related to the developing countries. Although networks exist, firmer links could be forged to achieve the multidisciplinary approaches needed for successful research on food processing, marketing, and agroindustries. A catalytic and coordinating mechanism should be established, principally by key national and regional programs in food and nutrition sciences and with technical support from the IARCs. Such a mechanism would benefit from IARC experience in research design, methodology development, and training in collaboration with national agricultural research systems. It may be appropriate in the initial stages to align national and regional networks on food processing with the commodity networks already implemented by the IARCs to provide integration and continuity. Appropriate procedures for involving IARCs with local institutions in this sector, consistent with the IARC mandate, should be elaborated. Stronger alliances in the developing countries with respect to postharvest research would demonstrate commitment that may be impossible in national institutions, which are subject to the vagaries of economics, policies, and supporting resources.

Assessment, modification, and application of the CIAT model of setting up pilot projects for testing commodity processing, technologies, and markets, and to serve as training venues for national producers and researchers. The model is not merely demonstration but operational research and extension. In view of the systems concepts and interinstitutional collaboration required to establish and operate such projects, national institutions often face drawbacks in pursuing these initiatives. Again, strong regional or national networks on food processing, in regions served by the IARCs, would provide a firmer basis for developing this kind of collaborative activity.

Pursuit of ties with private industry to link agricultural and postharvest research with income-generating opportunities. A deeper understanding of industrial objectives, needs, and strategies would serve to gear such research more effectively to employment and income aims. A closer relationship between agricultural and postharvest researchers and industry, possibly by means of the systems discussed above, could further efforts to ensure that agroindustrial development augments sustainability of the environment.

Conclusion

The small, lightly built ancestors of modern humans survived and evolved for millions of years as a result of zoological inheritance and environmental circumstance. The quirk of fate that at some stage allowed early hominids to appreciate the value of the cutting edge and then to replicate it in the form of stone tools initiated the technological culture that characterizes the present world.

Many of our most recent technological activities, which fuel the rapid economic growth seen in several countries, threaten to undermine the environmental integrity on which human evolution has been nurtured. Whether it is accepted that food-sharing has been a major determinant of the development of humans or not, today, food is clearly inadequately distributed among the world's population. So far, our technological advances have not succeeded in overcoming hunger. On the contrary, the numbers of hungry people appear to be increasing. We have tended to overlook, or been unable to confront, the social, economic, cultural, and political factors that condition the relevance of technology. I hope that this publication will help agricultural, food, and nutrition scientists to better appreciate the human dimensions of their work and to seek ways of more explicitly addressing them.

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